Macroeconomic Volatility and Physical Capital Accumulation in Sub-Saharan Africa

Arthur Chopkeng Awounang, Maxime Niee Foning

ABSTRACT

The aim of this work is to study the influence of macroeconomic volatility on physical capital accumulation in Sub-Saharan economies. To do this, we relied on a panel of 18 countries in the region, covering the period 1980-2010. In addition, our measures of volatility are obtained after estimating a GARCH (Generalized autoregressive conditional heteroskedasticity) model on four macroeconomics indicators that are the terms of trade, the real effective exchange rate, the GDP's growth and the inflation rate. After using the LSDV estimator (least square dummy variables), we obtain the following results: (1) a one unit increase in the conditional standard deviation of the real effective exchange rate leads to a decrease of 0.011 percentage point of growth in the stock of physical capital per capita; However, greater trade and financial integration may cancel this effect. (2) With respect to GDP growth, one more unit in his standard deviation raises the growth of physical capital stock per capita of 0.0002 percentage point. And (3), there is no significant effect from the volatility of terms of trade and inflation rate, although with negative signs. Therefore, Governments should implement policies to enhance economic diversification and so, reduce vulnerability and volatility; we also need to promote the establishment of mitigation measures by financial and trade integration.

Keywords: Volatility, Physical capital, Sub-Saharan Africa, GARCH, Panel data.

JEL Classification: D81, E32, F21, O5

Authors

Arthur Chopkeng Awounang, University of Yaoundé II, Cameroon, faculty of economics and management science, c.arthur90@gmail.com
*we would like to thank prof. Georges Kobou for proofreading and suggestions.
Maxime Niee Foning, University of Yaoundé II, Cameroon, faculty of economics and management science maximefoning@gmail.com

Citation Arthur Chopkeng Awounang, Maxime Niee Foning (2014). Macroeconomic Volatility and Physical Capital Accumulation in Sub-Saharan Africa. *International Journal of Economic Sciences*, Vol. III, No. 2/2014, pp.

1 Introduction

Most macroeconomic variables exhibit high volatility in developing countries (Easterly and *al*. 2000; Hausmann and *al*. 2005). This volatility was even more pronounced in sub-Saharan African countries over the last decade, especially in the sub-period 2007-2010, in response to the vagaries of commodity prices (UNCEA, 2011; IMF 2012). Indeed, the growth of these economies is largely dependent on exports of commodities[1]; furthermore, all of them are in price taker situation on the market. Therefore, it is created an environment of uncertainty that could profoundly affect the investment in physical capital in its various forms, that is to say, private, public, and even FDI.

In its 2010 report on regional economic outlook, the IMF notes precisely for the SSA area a reversal of capital flows in the order of 3% of GDP since 2007. However, this period coincides with where the price of raw materials, and therefore the main macroeconomic indices have been the most volatile in the last thirty years (Mayer and Gareis, 2010; UNCTAD, 2010). In addition, a synoptic view of the investment rate since the early 80s shows that it is at high levels in period of relative stability[2], and lower levels during periods of high volatility[3] (Abaidoo, 2012). These findings seem to come then support the intuition that volatility would be an obstacle to the accumulation of physical capital in Sub-Saharan economies. Specifically, exogenous shocks to foreign trade increase volatility and hence uncertainty in domestic macroeconomic aggregates, disrupting the optimal investment decisions from economic agents (UNCTAD, 2010).

However, a theoretical cleavage exists in the understanding of this relationship: some economists (Hartman, 1972; Abel, 1983) suggest that volatility has a positive influence on the accumulation of physical capital. This reflection is based in particular on the assumption of convexity of the profit function; also considering Jensen's inequality, it appears that a higher price uncertainty increases the expected return of capital, thus increasing the capital stock and finally the desired investment. This fact is true for both concepts of capital stock and capital services[4] (Jorgenson and Griliches, 1967). On the contrary, taking into account the

[1] About 24% in 2009 according to the World Bank.
[2] 20% on average between 1980 and 1990, and about 18% over the next decade according to IMF data.
[3] About 16% between 2000 and 2010, according to IMF data.
[4] Capital stock is the stock of physical assets existing at a point of time; whereas From a production perspective, capital services is the flow of services generated by these assets during a given period.

irreversibility[5] of most investment projects, Dixit and Pyndick (1994) show that volatility has a negative effect. More specifically, when there are significant costs at market exit, economic agents prefer to postpone their investment decisions during volatile periods. Like that, they are waiting for more information to avoid ending up ex post at a disadvantage (Abel and Eberly, 1999). Nevertheless, irreversibility is weaker in the case of capital service. This conclusion was initially highlighted in the standard framework of expected utility maximizing, and strengthen in the broader context of aversion to disappointment (Aizenman and Marion, 1995). More recently, it has also been confirmed by Bloom (2007).

From the foregoing, it should be clear that irreversibility is not a sufficient reason to turn down the positive impact of volatility on the physical capital accumulation. Indeed, even in the presence of asymmetric adjustment costs, it can be shown that the optimal investment by a competitive firm continue to be a non-decreasing function of uncertainty (Caballero, 1991; Abel and Eberly, 1994). To reverse this, it is necessary to make additional assumptions such as imperfect competition or decreasing returns to scale. When combined with the irreversibility, they transform the marginal product of capital into a decreasing function of the capital stock (Caballero 1991). Under these conditions, the breakeven point increases with the degree of uncertainty, and if this effect is strong enough, it may outweigh the increase in expected profitability arising from the convexity of the profit function, which reduces investment. The intuitive reason is that in this case, the asymmetric nature of adjustment costs makes downside uncertainty more important than upside uncertainty: Because divestment is more expensive than investment, favorable shocks have a smaller effect on the profitability than adverse shocks, and firms become reluctant to invest ex ante to reduce the risk of being stuck ex post with unprofitable and irreversible projects.

Furthermore, if one takes into consideration the problem of capital aggregation according to the Cambridge Capital Controversy, the hypothesis of factor substitution from neoclassical orthodoxy that is no more valid here would be a supplementary reason to strengthen the concept of investment irreversibility; so that macroeconomic volatility would contribute to slow down physical capital accumulation.

Given these analytical reasoning, the need for supplementary responses generated a multitude of empirical studies. Hausmann and Gavin (1995) reported a negative association

[5] This means that the investment adjustment costs are asymmetric, that is to say higher for reductions in the amount of capital than for its growth. The irreversibility had already been highlighted by Bernanke (1983) and Pyndick (1988).

between different indices[6] of macroeconomic volatility and the investment / GDP ratio for a large sample of developing countries. This result is confirmed by Aizenman and Marion (1995), who further report that the differences in private investment level between these countries are strongly linked to the specific levels of macroeconomic volatility. Bleaney (1996) finds a more mixed result: the author notes that these volatility indices negatively affect growth performance of developing countries, but not the total investment. A similar result is obtained by Ramey and Ramey (1995), which also use data on the total investment for a panel of 92 countries over the period 1962-1985.

Serven and Solimano (1993) also estimated a private investment equation using panel data on a group of developing countries; they find a negative impact of volatility indices considered. Pyndick and Solimano (1993) come to similar conclusions. Ghura and Grennes (1993) carried out their studies on a panel of 33 African countries over the period 1972-1987; they find a negative partial correlation between the volatility of the real effective exchange rate and different macroeconomic aggregates.

Serven (1998) introduced a different measure of volatility after estimating a GARCH model on a panel of 60 developing countries; he concludes that the volatility of five key macroeconomic variables[7] has a negative influence on investment. Only the effect of terms of trade is not significant. Aizenman and Marion (1999) lead to a similar result. Bleaney and Greenaway (2001) consider a panel of 14 countries in sub-Saharan Africa over the period 1980-1995. They find that growth is negatively affected by the volatility of terms of trade and investment by the volatility of the real exchange rate. Serven (2003), Pradhan et al. (2004) and Bhandari and Upadhyaya (2008) arrive at similar results. Using a panel of 87 developing countries, Addison and Wodon (2007) show that the growth of real GDP per capita over the period 1980-1994 was based on productivity growth and investment rates that both were negatively affected by the volatility of terms of trade, of real exchange rate, and of public investment.

So far, the physical capital stock is considered a basic way as the share of investment in GDP. From there, authors such as Cavalcanti et al. (2011) used a measure of capital as defined in the Solow model, taking into account the depreciation rate. Then they consider this value as a dependent variable in the regression of a panel of 118 countries in Sub-Saharan Africa, Europe and Asia over the period 1970-2007. The sample includes 62 countries

[6] That combines among other, volatility of real GDP and of real exchange rate.
[7] GDP growth, inflation, real exchange rate, terms of trade and relative price of capital.

exporting raw materials. The findings show that volatility of terms of trade of raw materials negatively affects the accumulation of physical capital in countries that are heavily dependent on exports of natural resources.

The objective of this paper is to study the influence of macroeconomic volatility on the accumulation of physical capital in Sub-Saharan economies. This study is more appropriate than the need to maintain and increase the amount of capital available to each individual allows us to make more inclusive growth in our economies (IMF, 2011). Moreover, taking into account a more accurate measurement of the stock of physical capital over a wider time range will certainly enable us to reach more conclusive results.

The remainder of this paper will therefore take place as follows: Section II presents the underlying theoretical corpus while the details of the methodology used is exposed along section III. Analysis and discussions of the main empirical results are the subject of Section IV; and Finally, Section V will allow us to conclude.

I. Theoretical foundations

This study is based on the theory of "aversion to disappointment"[8] already used by Aizenman and Marion (1995). They show that under irreversibility and appropriate assumptions about the degree of disappointment aversion, this theory can produce a more significant negative impact of volatility on the accumulation of physical capital relative to that obtained in the conventional framework of expected utility. Indeed, the authors argue that when agents preferences are entered through the generalized model of expected utility (aversion to disappointment), they always pay more attention to the expectations for the poor results than those who are favorable. Therefore, there is nonlinearity in these preferences, and volatility has an order 1 effect on aggregate investment that is proportional to the standard deviation of shocks rather than an effect of order 2 proportional to their variances. This assumption seems more realistic for SSA economies: The weakness and instability of macroeconomic performances, as well as relatively frequent political instability in the region lead most of the time to give priority to negative expectations from local and foreign investors. Therefore, they prefer to postpone or cancel their investments because they believe that their profit will end up being altered.

In addition, volatility also raise the difficulties of budget management by increasing uncertainty on public tax incomes (Ehrhart and Guerineau, 2011), and also by encouraging

[8] For more information, see Gul, F. (1991), "A theory of disappointment aversion." Econometrica 59, 667-86.

the phenomenon of debt intolerance (Catão and Kapur, 2006). This leads to a weak sustainability and even abandonment of public investments that are strategic in improving the competitiveness of the private sector. Positive externalities in terms of cost reduction are lost, and the investment decision becomes binding.

II. Methodology and data

- **Model specification**

In order to analyze the influence of macroeconomic volatility on the accumulation of physical capital in Sub-Saharan economies, we borrowed a panel data model from Shioji and Khai (2011). It has been implemented to test the determinants of physical capital accumulation in the context of Asian countries. By readjusting it to the sub-Saharan environment, that is to say taking into account a number of atypical variables, we finally obtain the following specification:

$$CK_{it} = \gamma + \alpha_1 \sigma TDE_{it} + \alpha_2 \sigma CPIB_{it} + \alpha_3 \sigma INF_{it} + \alpha_4 \sigma TCERit + \beta_1 lnTG_{it} + \beta_2 lnOC_{it} + \beta_3 lnPFI + \beta_4 lnSTI_{it} + \beta_5 lnIDE_{it} + \beta_6 ASP_{it} + \mu_i + \eta_t + \xi_{it} \quad (1)$$

Where we have:

CK = growth rate (first log difference) of the stock of physical capital per capita.

σTDE, σCPIB, σINF, σTCER = respectively, the volatility of terms of trade, of the GDP growth, of inflation rate and of the real effective exchange rate. This choice is dictated by the fact that theyare the most unstable aggregates in the studied countries (Easterly et *al*., 2000, Hausmann et *al*., 2005).

LnTG, LnOC, lnPFI, lnIDE and lnSTI = respectively the logarithms of the size of government, trade openness, financial development, foreign direct investment and industrial structure. The first three elements do not have to prove themselves in determining the evolution of the stock of physical capital. In other words, it is the role of the state, the role of technology transfer, and finally the level of performance of the financial sector (Serven, 2003; Addison and Wodon 2007; Cavalcanti et al, 2011). As for the last two, they are still more characteristic of sub-Saharan African countries:on the one hand, the small amount of local investment makes the level of FDI extremely important for the accumulation of physical capital (Abdul et al, 2007); on the other hand, a significant share of GDP comes from agricultural sector, which requires a relatively small amount of capital in relation to industrial sector. Thus, we can think that the predominance of the agricultural sector, measured by the

share of GDP from the industrial sector (STI) is negatively bond to the accumulation of physical capital (Shioji and Khai, 2011).

ASP = ln (100+ inflation rate) is an index of price stability which also helps to understand the level of risk for investors (Cavalcanti et al, 2011); and finally, μi and ηt are respectively individual and time-specific effects.

- **Data construction and Sources**

- The stock of physical capital

Data are generated on the stock of physical capital K by applying the perpetual inventory method, as Caselli (2005) did. Therefore, the perpetual inventory equation is given by:

$$K_{it} = (1- \rho)K_{it-1} + I_{it} \qquad (2)$$

Where I represent the investment rate, and ρ the depreciation rate. I is obtained by using data from Penn World Tables (PWT) 7.1[9]. It represents the real aggregate investment in terms of purchasing power parity (PPP). It is calculated by the following formula:

$$I_{it} = ki_{it} * rgdpch_{it} * pop_{it} \qquad (3)$$

Where ki is the share of investment in the real per capita GDP (rgdpch) and pop is the population. These variables are from the PWT 7.1. Based on the fact that data are fully available for all countries of the sample for the year 1970, we take it as reference year (year t_0) to calculate the initial capital stock as follows:

$$K_{it0} = I_{it0}/(gI + \rho) \qquad (4)$$

Where gI is the geometric growth rate of the aggregate investment between time t_0 and time t_{0+10}. The choice of this formula for calculating the initial capital stock is because it is the expression of the equilibrium capital stock in the Solow growth model. Following the literature (Caselli, 2005; Cavalcanti and *al.* 2011), the depreciation rate of capital is stated at 6%.

[9]For more information, see Heston, A., R. Summers, and B. Aten. 2012. Penn World Table Version 7.1. Center for International Comparisons of Production, Income and Prices, University of Pennsylvania.

- The volatility of macroeconomic indicators

First note that the volatility measures the amplitude and speed of the changes in values of asset prices or economic variables for a given period of time. It is also commonly seized in terms of prediction error; thus, the series may have important differences in values from one period to another, or values that are very far from the average value, but as the conditional mean is capable to explain most of the variance, this series cannot be considered volatile. It's also relevant to make a distinction between ex-post and ex-ante volatility: The first is calculated based on historical data, often using the standard deviation, while the second allows for an estimate of future behavior of the series. Much more precise and often obtained as a result of an autoregressive conditional heteroskedasticity (ARCH) model, it is the latter that will be used here. Therefore, according to the Akaike Information Criterion (AIC) and the partial autocorrelation graphics, we use a GARCH (1, 1) model formed by the following two equations:

$$Y_{it}= \alpha_0+\alpha_1 t+\beta_1 Y_{it-1}+\xi_{it} \qquad (5)$$

$$\sigma^2_{it}= \gamma_{i0}+\gamma_{i1}\xi^2_{it-1}+ \theta_i\sigma^2_{it-1} \qquad (6)$$

Where $\xi_{it} \sim N(0, \sigma^2)$; σ^2_t is the variance of ξt, conditionally on information available at time t. γ_{i1} is the ARCH parameter and the GARCH parameter is θ_i. This model is estimated for the entire panel, and the square root of the resulting series of σ^2_{it}[10] is used as a proxy for the volatility of the macroeconomic indicator considered.

Remainder data were obtained from the World Development Indicators CD-ROM 2012. The study is carried out over the period 1980-2010 and for 18[11] countries in the region.

III. Estimates and results

First, the panel analysis actually requires that all the variables of the study are stationary. Similarly, stationary is required to apply the GARCH model. So, every time we implement the Im et al. (2003) and Levin et al. (2002) tests to verify.

[10] That is to say, the standard deviation, in agreement with the underlying theory chosen here.
[11] Benin, Botswana, Burkina Faso, Burundi, Cameroon, Central African Republic, Congo, Gabon, Ghana, Ivory coast, Kenya, Lesotho, Mali, Niger, Senegal, Sudan, Togo and Zambia.

Table A: Results of unit root tests

VARIABLES	INTEGRATION DEGREE
CK	I(0)
TDE	I(1)
CPIB	I(0)
TCER	I(1)
INF	I(0)
σTDE	I(0)
σCPIB	I(0)
σTCER	I(0)
σINF	I(0)
lnTG	I(0)
lnOC	I(0)
lnSTI	I(0)
lnIDE	I(0)
lnPFI	I(1)
ASP	I(0)

As one can see, there are some variables that are not stationary; to correct this problem, we just take the first difference of the corresponding data. Then, we obtain, using the pattern formed by the equations (5) and (6), the estimated standard deviations of the error terms. They are used, we recall, as a proxy for the volatility of selected macroeconomic indicators; so, the new series obtained are introduced in equation (1).

Finally, the utilization of the Hausman test (1978) defines the structure of fixed effects to be more appropriate. Therefore, the application of the method of least squares with dummies variables (LSDV) provides the expected results. We used the "robust" option to correct for autocorrelation.

Table B: correlation matrix of the relevant variables

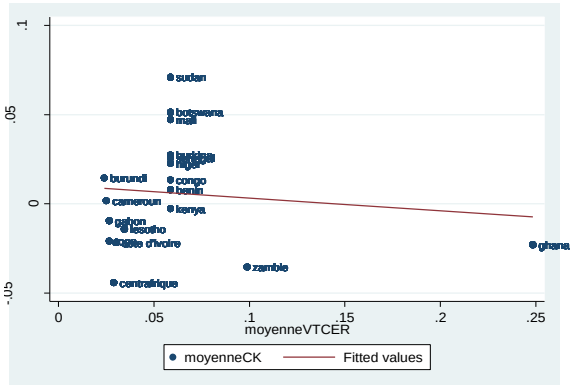
	CK	σTDE	σINF	σCPIB	σTCER
CK	1.0000				
σTDE	-0.1301**	1.0000			
	(0.0024)				
σINF	-0.0619	0.1031**	1.0000		
	(0.1510)	(0.0149)			
σCPIB	-0.0599	0.0876**	0.0734	1.0000	
	(0.1646)	(0.0386)	(0.833)		
σTCER	-0.0704*	0.0657	0.1453***	0.0329	1.0000
	(0.0922)	(0.1212)	(0.0006)	(0.4380)	

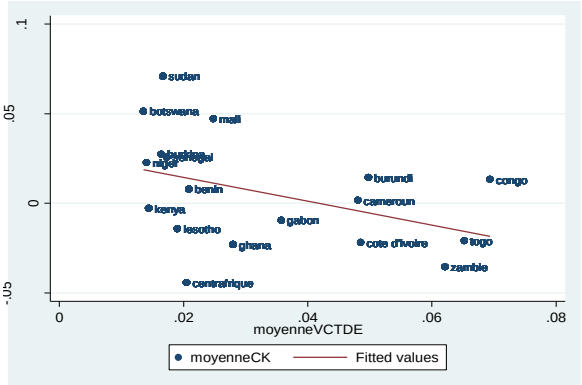
Note: ***, **, * respectively represent significance at 1, 5 and 10%. The values in parentheses are the probabilities

As a preliminary, a statistical investigation is conducted. It leads in particular to the fact that there is a priori, a negative relationship between the volatility of selected macroeconomic indicators and the accumulation of physical capital. However, this relationship appears to be more pronounced when it comes to the volatility of the real effective exchange rate and terms of trade; whereas for the other indices, the effect is more mixed. These conclusions are obtained through the analysis of correlation coefficients table **(Table B)**, but also using different graphical trends from the points clouds **(Figure 1 to 4)**.

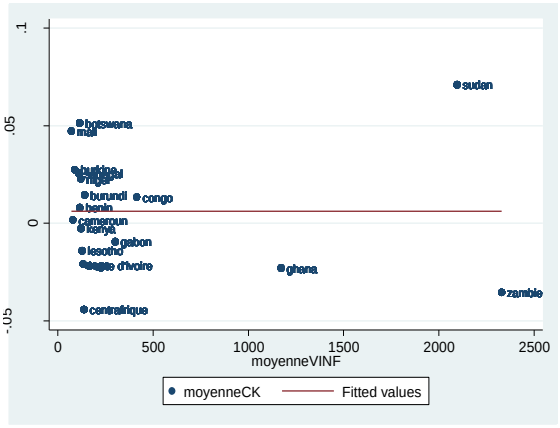
Figure 1 to 4: average growth of the stock of physical capital in terms of the average volatility of the relevant variables for the 18 countries considered, from 1980 to 2010.

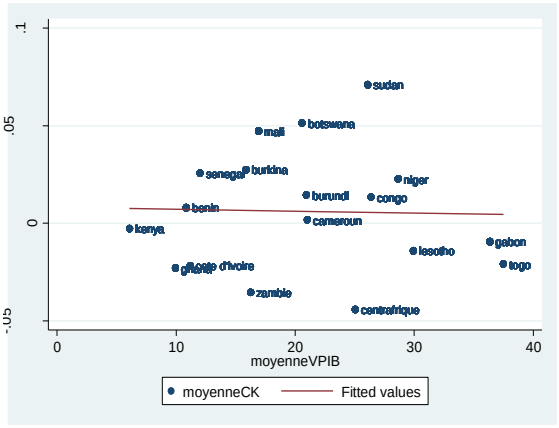
1. **2.**





3. **4.**





Source: author.

What about the results of the econometric regressions?

Overall, it appears from **Table C** that macroeconomic volatility has a negative impact on the accumulation of physical capital. The volatility of the inflation rate, of the terms of trade and of real effective exchange rate negatively affects investment. However, the results indicate a positive effect of GDP's growth volatility.

Table C: Results of the model estimation

	CK	CK	CK	CK	CK
LnTG	-0.033	-0.033	-0.032	-0.033	-0.032
	(4.51)***	(4.53)***	(4.46)***	(4.65)***	(4.51)***
LnOC	0.025	0.024	0.027	0.024	0.024
	(2.27)**	(2.09)**	(2.43)**	(2.07)**	(2.08)**
LnIDE	0.002	0.002	0.002	0.002	0.002
	(2.09)**	(2.02)**	(2.12)**	(2.02)**	(2.00)**
ASP	-0.153	-0.150	-0.153	-0.147	-0.143
	(3.77)***	(3.77)***	(3.84)***	(3.16)***	(3.07)***
LnPFI	0.031	0.033	0.032	0.032	0.035
	(3.06)***	(3.22)***	(3.16)***	(3.08)***	(3.34)***
LnSTI	-0.041	-0.042	-0.041	-0.041	-0.042
	(1.98)**	(2.01)**	(1.99)**	(2.09)**	(2.11)**
σTDE	-0.008				-0.001
	(0.25)				(0.05)

σTCER		-0.011			-0.012
		(4.04)***			(3.78)***
σCPIB			0.0002		0.000
			(1.72)*		(1.80)*
σINF				-0.000	-0.000
				(0.34)	(0.31)
_cons	0.269	0.263	0.273	0.255	0.251
	(3.45)***	(3.45)***	(3.56)***	(2.77)***	(2.71)***
R^2	0.59	0.59	0.59	0.59	0.59
N	438	438	438	438	438

Note: * $p<0.1$; ** $p<0.05$; *** $p<0.01$. Values in ( ) represent the student statistics.

Regarding the negative effects, only the volatility of the real effective exchange rate has a significant parameter. Therefore, we confirm the findings of Ghura and Grennes (1993), but also Bleaney and Greenaway (2001). This simply means that increased uncertainty about the evolution of the real effective exchange rate is an impediment to investment in SSA. Specifically, a unit increase of the conditional standard deviation of the real effective exchange rate leads to a decrease of 0.011 percentage points of growth in the stock of physical capital per capita. This can be explained in several ways: firstly, the TCER appreciation encourages investment in the tradable sector, as their prices increase relatively to other goods, but discourages them in the case of non-tradable goods because of the increasing purchasing

power of consumers and therefore imports. By cons, if there is depreciation, it has the opposite effect. Therefore, the volatility and hence uncertainty about this rate incite investors to wait for more information to know which of these two sector will be the most profitable (Hau, 2000). This scenario is frequent in our countries, since we are hardly able to control the movements of our real effective exchange rates.

Secondly, investments often require capital goods which are not available in the Sub-Saharan economies. Their production takes time and price uncertainty caused by volatile movements in the TCER can lead investors to postpone their orders. Furthermore, Campa and Goldberg (1995) argued that industries with relatively high margins rate are less affected by the volatility of the real effective exchange rate, as well as those that do not greatly import their inputs. But most sub-Saharan firms are working in the primary sector and still have low margin; in addition, the raw materials used are largely imported in the whole production chain.

Finally, it has also been showed intuitively as well as empirically that the volatility of the real effective exchange rate has a greater effect on countries with low trade openness or that have a sluggish financial sector (Hau, 2000; Serven 2003). These two features almost perfectly summarize the situation of sub-Saharan economies, and thus, allow to grasp the fact that they are negatively affected by the unpredictable movements of this rate. We will see this in more detail in the explanation of the results devoted to the estimation with interaction terms.

Let us analyze the only positive correlation found. Although the coefficient is weakly significant, the volatility of GDP growth has a positive effect on the accumulation of physical capital. Specifically, a unit increase of the conditional standard deviation of the growth rate results in an increase of 0.0002 percentage point of growth in the stock of physical capital per capita. This result is similar to that of Abaidoo (2012). The author finds that an additional unit of conditional standard deviation of the growth rate increases investment of 0.003% and growth of 0.30% in sub-Saharan Africa. This seems rather unlikely, but still has a plausible explanation. Indeed, Dotsey and Sarte (2000) conclude that for degrees of aversion to risk large enough, an increase in volatility causes an increase in precaution investment, often at the expense of consumption. This is also the reasoning of Smith (1996) and De Hek (1999). The period of volatility therefore pushes agents to invest in order to diversify their portfolios and thus smooth their income and future consumption.

Serven (2003) shown that the volatility of the real effective exchange rate negatively affects investment only in countries with low openness or with low financial depth. His work is based on the original theory of Hau (2000). To try to confirm this hypothesis in the context of sub-Saharan economies, we have successively included in equation (1) the interaction terms (σTCER * OC) and (σTCER * PFI). The results are shown in **Table D**.

Table D: estimation with interaction terms

	CK *(a)*	CK *(b)*	CK *(c)*	CK *(d)*
lnTG	-0.033	-0.034	-0.033	-0.031
	(4.45)***	(4.64)***	(4.51)***	(4.21)***
lnOC	0.024	0.028	0.022	
	(2.14)**	(2.48)**	(1.92)*	
lnIDE	0.002	0.002	0.002	0.003
	(2.01)**	(1.82)*	(2.01)**	(2.51)**
ASP	-0.144	-0.175	-0.156	-0.165
	(3.42)***	(4.33)***	(3.70)***	(3.94)***
lnPFI	0.031		0.033	0.035
	(3.01)***		(3.23)***	(3.43)***
lnSTI	-0.042	-0.040	-0.042	-0.043
	(1.99)**	(2.02)**	(2.02)**	(2.03)**
σTCER	-0.022	-0.038	0.009	0.042
	(1.40)	(1.71)*	(0.39)	(1.36)
σTCER*PFI	0.036	0.094		
	(0.75)	(1.41)		
σTCER*lnOC			0.019	0.052
			(0.89)	(1.82)*
_cons	0.252	0.313	0.272	0.282
	(3.15)***	(4.02)***	(3.42)***	(3.56)***
R^2	0.59	0.58	0.59	0.58
N	438	438	438	438

Note : * p<0.1; ** p<0.05; *** p<0.01. Values in ( ) represent the student statistics.

As we can see, *column d* show that the interaction term between the volatility of the real effective exchange rate and trade openness has a positive sign with significance at 10%. In addition, the sign of the volatility of the real effective exchange rate is also positive but not significant. This allows us to confirm the previous theoretical and empirical results (Hau, 2000; Obstfeld and Rogoff, 1999; Serven, 2003): growing trade openness allows mitigate the adverse effects of real effective exchange rate volatility.

This result can be explained simply by the fact that in case of real supply shocks or monetary shocks, monetary equilibrium requires a greater change in the nominal exchange rate if the adjustment of the relative price level is made by the bias of the exchange rate for countries with a small amount of tradable goods. Trade openness is thus negatively related to volatility. However, this effect becomes insignificant when the interaction term is taken into account at the same time with the volatility of the real effective exchange rate and trade openness (*column c*).

Financial depth also seems to have inhibitory effects on the consequences of volatility, since the interaction term is positive but not significant in *columns (a) and (b)*. Indeed, the efficiency of the financial market can act as a safety net in case of unfavorable position ex post to the investment decision.

IV. Summary and Conclusion

This paper has used the methodology of panel data to analyze the influence of macroeconomic volatility on the accumulation of physical capital in 18 countries in sub-Saharan Africa. We chose the four most relevant macroeconomic indicators in the context, namely GDP growth, terms of trade, inflation rate and real effective exchange rates. Finally, the debate on the sign of the relationship seems to depend on the index considered and thus on the spatial nature of the study. Indeed, we obtain a positive impact of the GDP's growth volatility, while the rest of the indicators seem to slow the accumulation of physical capital. That is particularly the case with the uncertainty of movements in the real effective exchange rate. We also find that the latter effect can be mitigated by greater trade openness, but also by increasing the dynamism of the financial sector of the concerned economies. Policy makers should therefore implement measures to promote both.

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